Small Diameter Well Variance Guideline

A. Introduction

In recent years, direct push technology (DPT) has been used to investigate both soil and groundwater contamination. Technological advances have resulted in the ability to install small diameter groundwater monitoring wells using direct push technology. Published studies indicate that contaminant concentration data from direct push wells compare favorably to data from traditional drilled wells (Kram, et. al., 2001; BP and EPA Region 4, May, 2002). Direct push wells cost less than drilled wells, minimize or eliminate soil cuttings, and expose the workers to less chemical exposure during installation. Due to the convenience and the cost savings of using this technology, there has been increasing demand to use this method to install permanent small diameter wells.

In addition, this guideline will allow, in certain circumstances, a small diameter well to be installed in an open hole.

Pursuant to the current State of California Well Standards (Department of Water Resources, DWR, Bulletins 74-81 and 74-90), groundwater wells shall have a minimum annular space of two inches around the well casing and screen. The intent of the Standards to specify a minimum annular space is to minimize the potential of bridging during placement of the sand pack and seals and to increase the potential of a properly placed annular seal.

Small diameter wells cannot meet these prescribed construction standards because of the insufficient annular space created by the small diameter of the borehole. However, DEH has the authority to approve variance to the standards if the well design meets the intent of the State Well Standards. Therefore, DEH has established these guidelines to allow a variance for the construction of permanent small diameter wells having effective sand packs and annular seals following the intent of the Bulletins.

Please be aware that nothing in this guideline relieves the driller and/or the registered professional from their responsibility for:

- Properly installing the well in accordance with applicable state and local regulations and guidelines.
- Preventing the well from being a potential environmental threat to water quality.
- Assuring that the well will be designed and constructed to yield representative samples, usable hydrologic data, and have a useful lifetime.

DEH, under its well permitting authority, reserves the right to modify or deny any variance.

B. General Considerations

1. Definition of Small Diameter Well

A "small diameter well" for the purpose of this document is a well that cannot be constructed by conventional methods with a borehole of less than 6 inches diameter while maintaining a minimum of a 2 inch annular space around the casing.

The "small diameter well" must have an annular space of sufficient size to allow verifiable emplacement of sealing materials.

This variance guideline does not apply to other well geometries.

2. San Diego County Well and Boring Standards

The installation of small diameter wells shall follow all sections of the San Diego County Well and Boring Construction Standards in Appendix B except for specific variances allowed in this guideline. Unless otherwise specified in this section, all standards listed in the California Department of Water Resources Bulletins 74-81 and 74-90 will apply to small diameter wells.

A small diameter well is a "variation from the methods and or procedures presented in the requirements for the construction of Vadose and Ground Water Monitoring Wells (Current SAM Manual Requirements)" and, therefore, must be identified as such in answering Question 9 of the Permit Application for Ground Water and Vadose Monitoring Wells, Exploratory or Test Borings.

The purpose of this guideline is to help qualified professionals propose an acceptable construction of a small diameter well.

3. Site Selection

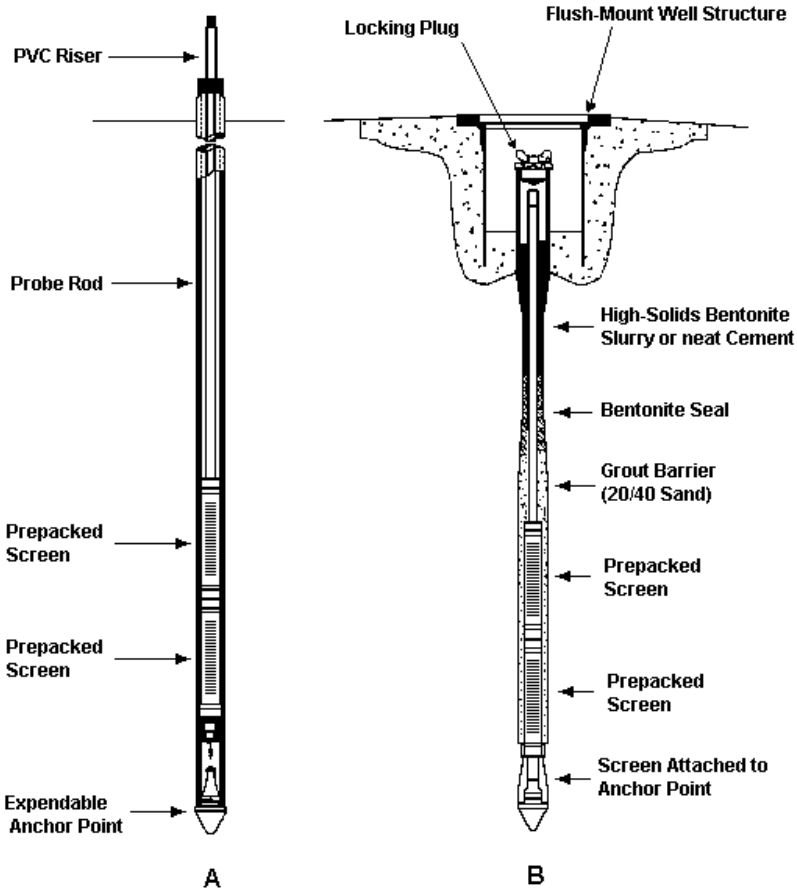
The ability to install small diameter wells depends on having favorable geologic and hydrologic conditions at the site. Additionally, this guideline specifies conditions where these technologies are permitted.

The subsurface geology and water table elevation at the site shall be sufficiently understood to allow the proper choice of a filter pack and selection of a screened interval before a small diameter well is constructed.

The subsurface geology must be verified by continuous logging during the installation of small diameter wells.

4. Well Design

Only professionals having the qualifications listed in Appendix B may design small diameter wells. The professional should review available well and boring logs for the site and immediate vicinity along with sample data to design the well. Design the wells in accordance with the standards in Appendix B. Do not use pre-packed bentonite seals for transition or annular seals above the water level in the borehole because the proper expansion of the seal cannot be assured in unsaturated conditions.



5. Overview of DPT Well Installation

A DPT rig is a hydraulically powered machine that utilizes static force and hydraulic rams and/or percussion to advance small diameter sampling tools into the subsurface for making *in-situ* measurements or collecting soil core, soil gas, or groundwater samples. The DPT rig pushes tools into the ground using rods with a typical outside diameter of approximately two inches.

The components of a DPT well consist of the following:

- An expendable conical push point that becomes the anchor and bottom cap of the well.
- A length of manufactured well screen with attached filter pack, also known as a "prepacked well screen."
- Material to support a bentonite transition seal above the prepacked screen, such as a manufactured annular bridge attached to the well casing, or sand tremied into the annular space surrounding the prepacked screen, or collapse of natural formational material.
- A bentonite transition seal that prevents liquid grout from reaching the screened interval.
- Riser pipe.
- Properly installed annular seal materials.
- Standard surface seal and wellhead protection.
- If a portion of the annular seal is constructed below water level in the hole, prepacked bentonite seals are used for both the transition seal and the annular seal below water level in the hole.

For well construction, the push rods are advanced to the correct depth, then the prepacked well screen, optional annular bridge, prepacked bentonite seal (if appropriate), and riser pipe are assembled and lowered through the inside of the push rods.

The bottom of the well assembly is attached to an expendable anchor point that becomes the bottom cap of the well. After the well assembly is anchored, the push rods are retracted. As the rods are retracted above the prepacked screen, either natural formation collapses around the screen or (if no annular bridge or prepacked bentonite sleeve is used) sand of the appropriate size is poured through the rod annulus to a level six inches above the screen.

A bentonite transition seal six inches in thickness is placed above the filter pack to prevent grout from penetrating into the screened interval. Grout conforming to the

requirements in Appendix B is then installed in the annulus to form an annular seal.

These procedures are presented in more detail in the following sections.

Once the well is set, the surface seal and well head completion is constructed in accordance with SAM Manual Appendix B.

6. Overview of Open Hole Construction of Small Diameter Wells

Open hole construction is performed in small diameter boreholes created by equipment other than hollow-stem auger or DPT. Open hole construction is limited to wells no greater that 20 feet in depth from the ground surface. Additionally, the walls of the borehole must be stable when unsupported.

All requirements in Appendix B regarding the design and construction of groundwater monitoring wells apply to small diameter wells constructed in open holes, except for the characteristics unique to small diameter wells and techniques unique to open hole construction specified in this guideline.

Once the open borehole has been excavated, the well materials, consisting of a bottom cap, well screen, riser pipe, and centralizers, are assembled and lowered into the hole. Centralizers are required at the bottom, top, and at an appropriate location in the center of the well assembly.

Appropriate materials are then poured into the borehole to form the sand pack, transition seal, and annular seal, in accordance with San Diego County Standards for well construction in Appendix B. In addition, as materials are added, the filling of the hole is monitored using a rigid device to measure the depth to the top of the material. If the measurements indicate bridging or other conditions that could create voids, corrective action is taken before adding more material. These procedures are presented in more detail in the following sections.

Once the well is set, the surface seal and well head completion is constructed in accordance with SAM Manual Appendix B.

7. General Equipment and Materials

a) Equipment

DPT equipment is manufactured by several companies and sold under various names. Similarly, there are a wide variety of small-diameter solid-stem auger and hand auger rigs available. Any of these rigs are suitable for the installation of small diameter wells. The equipment must be inspected and maintained in accordance with the requirements in Appendix B. The operator of any of this equipment must meet the requirements for “Drilling Company” in Appendix B.

A grout pump is required to install annular seals.

b) Permits

An approved Groundwater Monitoring Well permit is needed prior to installation of the wells. A well construction diagram must be submitted for any permit application for a small diameter well. In the appropriate area on the permit application, identify that the proposed well will be a small-diameter well and, if applicable, identify if the well will be constructed in an open hole. Identify the type of equipment to be used (DPT, solid-stem auger, or hand auger). Identify any other proposed variances from the well standards or these guidelines. More information regarding how to complete the Groundwater Monitoring Well permit application is presented in Appendix B.

c) Well Materials

At a minimum, the following well materials are needed at the site to properly construct a DPT small diameter well:

- Pre-packed Screen;
- Expendable Anchor Point/Bottom Cap;
- PVC Riser with 0-rings or a SAM-approved alternative between the riser pipe sections;
- PVC Top Cap;
- Well Cover (aboveground or flush-mount);
- Annular Bridge or Sand, 20/40 grade;
- Granular bentonite (passing #8 mesh);
- High-solids bentonite grout;
- Portland Cement;
- Type I Concrete Mix (premixed cement and aggregate);
- A rigid measuring device that will fit down the small annular space;
- Clean Water;
- Decontamination Equipment for all down-hole rods and equipment.

All well materials must conform to the other requirements listed in Appendix B.

8. Soil Description/Sampling

Soil Descriptions sampling, and documentation of depth to groundwater must be performed in accordance with Appendix B. Because DPT does not inherently produce materials that can be logged, such as soil cuttings, the subsurface geology by continuous logging technique such as continuous coring or Cone Penetrometer

Test (CPT). If CPT data is used, soil classification (using a referenced CPT classification system) must be provided as well as the raw strain gauge data. Depending on the level of information available, the degree of verifiability needed may be reduced on a case-by-case basis with a variance issued by DEH.

The geology and water table shall be depicted on a well log and submitted with the well log report in accordance with the requirements of the well permit. The source of the geologic data (continuous coring, CPT, etc.) shall be clearly stated on the well log.

9. Well Destruction

All failed or unsuccessful small-diameter well installations must be destroyed according to California Standards and within 24 hours of construction. Small diameter wells shall be destroyed in the same manner as any groundwater or vadose well.

C. Small Diameter Well Construction Guidelines

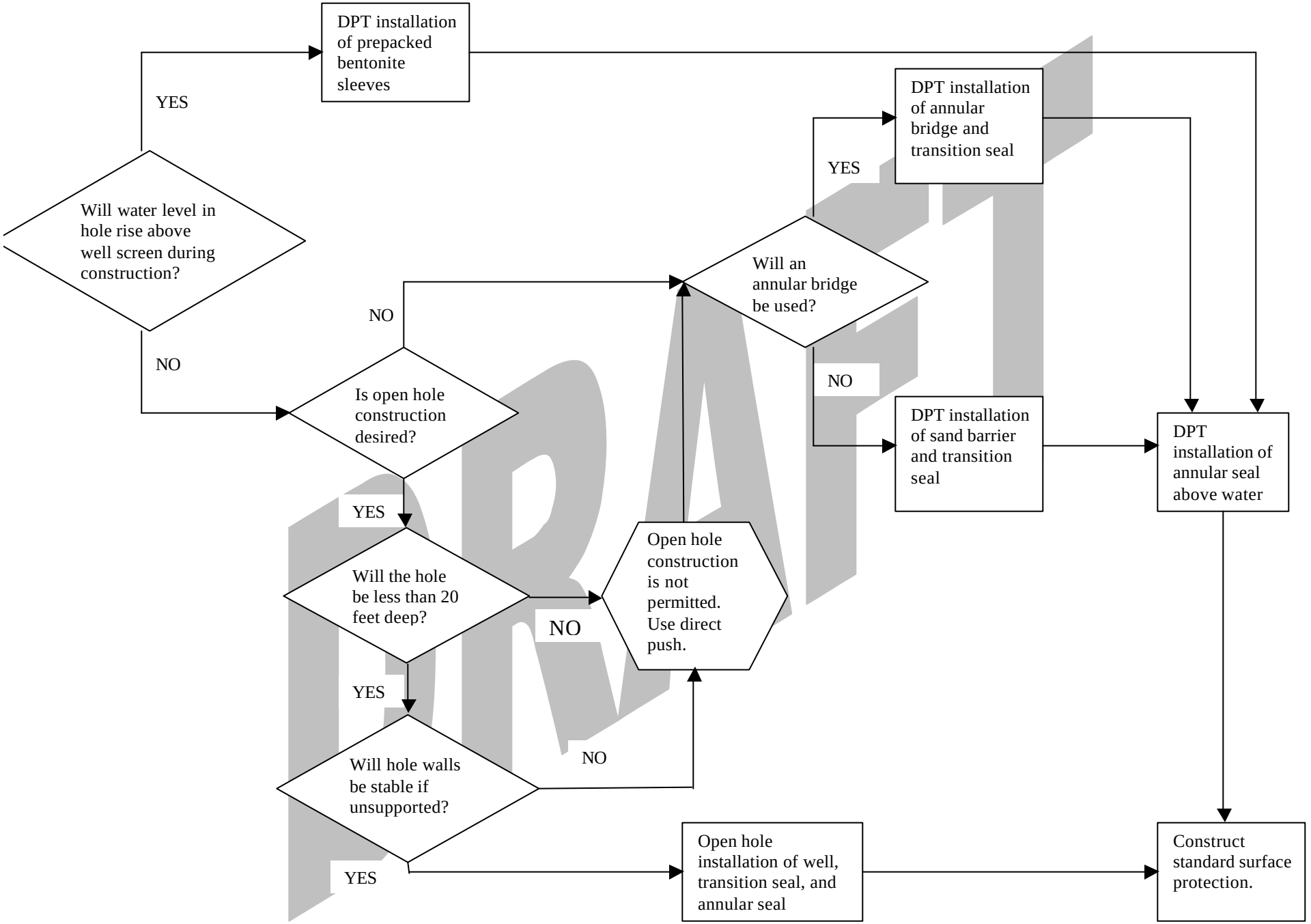
This section presents five separate procedures for use in the construction of small diameter wells:

1. DPT installation of sand barrier and transition seal.
2. DPT installation of annular bridge and transition seal.
3. DPT installation of wells using prepacked bentonite sleeves below water level in the borehole.
4. DPT installation of annular seal above water level in well.
5. Open hole installation of well, transition seal, and annular seal.

The flowchart in Figure X-X guides the decision of which procedure(s) are appropriate for the proposed well installation. Note that information about the subsurface is required in order to decide which procedures to use.

Information regarding the depth to water at the site must be known. Not only is this information required (as with any well) to properly design the well in accordance with the requirements of Appendix B -- this information is also needed to plan the special materials needed and procedures to be followed for a small diameter well. For example, if water level in the borehole rises completely above the screened interval during construction, and therefore sealing materials need to be installed below water in the borehole, then prepacked bentonite sleeves should be used to seal the interval below water level in the borehole.

Also, if open hole construction is desired, the geologic materials must be of a type not given to caving, sloughing, expansion, heaving, flowing, or other characteristics that would cause closure or in-filling of an open borehole. The project site and subsurface geologic conditions must be evaluated by a qualified professional, and a certification be made that the site geologic conditions are suitable for open-hole construction of wells. Accompanying the application for a permit, a summary of the evaluation must be included to justify the use of this method.


DPT installation of prepacked bentonite sleeves
YES
Will water level in hole rise above well screen during construction?
NO
Is open hole construction desired?
YES
Will the hole be less than 20 feet deep?
YES
Will hole walls be stable if unsupported?
YES
NO
Open hole construction is not permitted. Use direct push.
NO
NO
Will an annular bridge be used?
YES
DPT installation of annular bridge and transition seal
NO
DPT installation of sand barrier and transition seal
DPT installation of annular seal above water
Open hole installation of well, transition seal, and annular seal
Construct standard surface protection.

The following are the details for the five procedures listed above and presented in the flow chart (Figure X-X).

1. DPT installation of sand barrier and transition seal.

a) Overview

- Shall be constructed with a prepacked well screen that is designed to span the water table.
- Shall have a sand barrier filling the annular space adjacent to the prepacked well screen and extending to six inches above the top of the screened interval. The purpose of the sand barrier is to prevent transition seal materials from reaching the depth of the screened interval.
- Shall have a transition seal six inches thick composed of properly hydrated granular bentonite used in accordance with manufacturer's specifications. The purpose of the transition seal is to prevent annular sealing materials from reaching the screened interval.
- The annular space from the top of the bentonite transition seal to the base of the surface seal shall be filled using the procedure for "DPT installation of annular seal above water level in well" below. A surface seal and well head shall be completed in accordance with Appendix B.
- As with all well construction, all quantities of sealing materials used shall be measured in units of volume and reported in the well log report.

b) Procedure for Anchoring Well Assembly

An expendable anchor point is driven to depth on the end of the push rods. A prepacked well screen assembly is inserted into the inside of the rod with sections of PVC riser pipe. The screens and riser pipe are attached to the anchor point to stabilize the assembly for installation.

(1) Affix the expendable drive point to the bottom push rod and advance the push rods to the designed maximum depth of the well.

(2) Lower prepacked well screen down the push rod with the appropriate end pointing down, per manufacturer's instructions. Add prepacked well screen sections as needed to achieve the designed screened interval.

(3) Attach sections of PVC Riser to the top of the screen assembly. Continue to add riser sections until the assembly hits the expendable drive point at bottom of rods. At least one foot of riser should extend past the top push rod. Plug the top riser to ensure that the inside of the well stays clean during construction.

(4) Attach the well assembly firmly to the expendable drive point in accordance with the manufacturer's instructions, ensuring that the bottom end of the screen is sealed. Gently pull up on the riser to ensure that the well assembly is firmly attached to the anchor.

(5) Begin retracting the push rods. While pulling the rods, observe whether the PVC risers stay in place or move up with the rods.

If the PVC risers move up with the rod string, the well is not anchored. Stop and take corrective action. First, check to be sure the pre-packed screen is still attached to the expendable drive point. Next, use precautionary measures to safely hold the PVC risers in place while pulling up the rods. An additional section of PVC riser may be helpful. Once the push rods have cleared the anchor point and part of the screen, the screen and riser assembly should stop rising with the rods.

If the PVC risers stay in place, the well is successfully anchored. Continue retracting the rods so that the bottom of the rods are no more than two feet above the top of the planned six-inch transition seal interval.

c) Procedure for Installing the Sand Barrier

The natural formation will sometimes collapse around and above the well screens as the push rod string is withdrawn. The collapse above the screens provides effective support for the transition seal. If the formation does not collapse, a sand barrier must be placed from the surface. This portion of the well installation procedure is important because an inadequate barrier will allow transition seal bentonite and perhaps grout to reach the well screens. Non-representative samples and retarded groundwater flow into the well result from bentonite or grout in the screened interval.

(1) Using a water level sounder or flat tape measure, determine the depth from the top of the PVC riser to the bottom of the annulus between the riser and push rods. Two scenarios are possible:

- Measured depth is 2 to 3 feet less than riser length. This indicates that unstable conditions have resulted in formation collapse. A natural base for the transition seal was formed as material collapsed around the PVC riser when the probe rods were retracted. This commonly occurs in noncohesive sands. A sand barrier cannot be installed due to the collapse of the formation. Proceed to the next section on installing the bentonite transition seal.
- Measured depth is equal to or greater than riser length. This indicates that stable conditions are present. The probe hole has remained open and void space exists between the riser (and

possibly the screen) and formation material. Clean sand must be placed down hole to provide a suitable grout barrier.

(2) Begin slowly pouring 20/40-grade sand pack down the annulus between the PVC riser and push rod string. Measure and record the volume of sand added.

Measure the annulus depth while adding sand. The sand may not fall all the way past the screens due to the tight annulus and possible water intrusion. This is acceptable, since the pre-packed screens do not require the addition of sand. It is, however, important that support for the transition seal is provided above the screens.

Add sand until it extends six inches above the screen section.

Sand may bridge within the annulus between the risers and push rods and consequently fail to reach total depth. Wet probe rods contribute to sand bridging. If no bridging has occurred, proceed to the next step.

In case of a sand bridge above the screens, insert a clean rigid device into the well annulus to break up the sand. Simultaneously retracting the push rods usually helps. Check annulus depth again. If sand is no longer bridged, proceed to the next step.

If the sand bridge cannot be broken up with a rigid device, inject a small amount of clean water into the annulus. This is accomplished using grout machine and tubing. Insert the tubing down the well annulus until the sand bridge is contacted. Attach the tubing to the grout machine and pump up to one gallon of clean water while moving the tubing up and down. The jetting action of the water will loosen and remove the sand bridge. Check annulus depth again. The distance should be 2 to 3 feet less than the riser length.

In general, avoid any procedure that will cause the inside of the push rods to get wet. Moisture inside the push rods will greatly increase the chance of bentonite bridging in the rod annulus when the transition seal is installed.

d) Procedure for installing Bentonite Transition Seal

Bentonite clay, when properly placed, prevents liquid grout and contaminants from moving down the annular space into the well screen. The seal is formed by placing granular bentonite into the annulus by gravity and hydrating in accordance with the manufacturer's instructions or by injecting high-solids bentonite slurry directly above the sand barrier. Bentonite chips should not be

used. The bentonite transition seal must extend at least six inches above the sand pack.

(1) **Stable Formation** - Granular bentonite is recommended if the following conditions are met:

- Formation remained open when probe rods were retracted.
- Bridging was not encountered while installing the sand pack and grout barrier.

The following procedure should be used:

i. Withdraw the probe rod string another 3 to 4 feet. Ensure that the PVC riser does not rise with rods.

ii. Measure the depth from the top of the riser to the bottom of the annulus. Pour granular bentonite between the probe rods and PVC riser as was done with the sand, measuring as the bentonite is added. Add bentonite to form a six-inch transition seal.

iii. Verify the thickness of the transition seal by measure the depth from the top of the riser to the bottom of the annulus. The distance should now equal the installed riser length minus the minimum six inches of sand pack and six inches of bentonite seal. As was stated with the sand pack, if the measured depth is significantly less than expected, the bentonite has more than likely bridged somewhere along the rod string. A procedure similar to that identified for bridged sand may be used to dislodge the granular bentonite.

iv. Once it has been determined that the bentonite seal is properly placed, use the grout pump and grout tube to pump sufficient water to the bentonite to hydrate it according to the manufacture's instructions.

(2) **Unstable Formation** - A grout machine is required. The pump must be able to supply high-solids bentonite slurry under sufficient pressure to displace collapsing soil.

i. The high-solids bentonite grout (20 to 25 percent by dry weight) must be used and placed by using a grouting machine.

ii. The grout must be delivered to the bottom of the annulus between the probe rods and well riser through a grouting tube.

iii. While pumping the bentonite grout slowly pull the rod string approximately 3 feet. This procedure will place bentonite in the void left by the retracted rods before it is filled by the collapsing formation.

iv. During this procedure measure the annulus depth to ensure that the bentonite was delivered.

e) Follow procedure for "DPT installation of annular seal above water level in well" below, and then construct surface completion in accordance with Appendix B.

2. DPT installation of annular bridge and transition seal.

a) Overview

- The well shall be constructed with a prepacked well screen that is designed to span the water table.
- The well shall have a manufactured device in the well assembly designed to bridge the annular space and prevent transition seal materials from reaching the well screen (i.e. an "annular bridge"). The annular bridge must meet all requirements in the General Considerations for Well Materials in Appendix B.
- The well shall have a transition seal six inches thick composed of properly hydrated granular bentonite used in accordance with manufacturer's specifications. The purpose of the transition seal is to prevent annular sealing materials from reaching the screened interval.
- The annular space from the top of the bentonite transition seal to the base of the surface seal shall be filled using the procedure for "DPT installation of annular seal above water level in well" below. A surface seal and well head shall be completed in accordance with Appendix B.
- As with all well construction, all quantities of sealing materials used shall be measured in units of volume and reported in the well log report.

b) Procedure for Anchoring Well Assembly

(1) Affix the expendable drive point to the bottom push rod and advance the push rods to the designed maximum depth of the well.

(2) Lower prepacked screen down the push rod with the appropriate end pointing down, per manufacturer's instructions. Add screen sections as needed to achieve the designed screened interval.

(3) Thread annular bridge onto to the top of the pre-packed screen.

(4) Thread the riser pipe to the top of the annular bridge.

(5) Lower well assembly into push rods until the annular bridge is approximately three feet into the push rods.

(6) Calculate the volume of granular bentonite that is needed to fill the annular space between the borehole wall and the riser pipe for six vertical inches. Measure the granular bentonite into the annular space between the riser pipe and the push rod so that it rests on top of the annular bridge. Note that the insides of the push rods need to be dry for this method to succeed.

(7) While holding the grout tube to well casing, push the riser pipe and grout tube down the push rod, adding riser pipe until screen hits the expendable drive point at bottom of rod string. At least one foot of riser should extend past the top push rod. Plug the top riser to ensure that the inside of the well stays clean during construction.

(8) Release the grout tube and attach the well assembly firmly to the expendable drive point in accordance with the manufacturer's instructions, ensuring that the bottom end of the screen is sealed. Gently pull up on the riser to ensure that the well assembly and anchor are firmly attached.

(9) Begin retracting the push rods. While pulling the rods, observe whether the PVC risers stay in place or move up with the rods.

If the PVC risers move up with the rod string, the well is not anchored. Stop and take corrective action. First, check to be sure the pre-packed screen is still attached to the expendable drive point. Next, use precautionary measures to safely hold the PVC risers in place while pulling up the rods. An additional section of PVC riser may be helpful. Once the push rods have cleared the annular bridge, the screen and riser assembly should stop rising with the rods.

If the PVC risers stay in place, the well is successfully anchored. Continue retracting the rods so that the bottom of the rod string rod is just above the end of the grout tube. The length of retraction equals the total length of screen + the length of the annular bridge + the thickness of the bentonite + the distance between the bentonite and the bottom of the grout tube.

(10) Use the grout pump and grout tube to pump sufficient water to the bentonite to hydrate it according to the manufacture's instructions. Wait for the bentonite to absorb enough water to form a barrier to liquid grout.

c) Follow procedure for "DPT installation of annular seal above water level in well" below, and then construct surface completion in accordance with Appendix B.

3. DPT installation of wells using prepacked bentonite sleeves below water level in the borehole.

a) Overview

- The well shall be constructed with a prepacked well screen.
- The well shall be constructed with properly installed prepacked bentonite seals for all riser pipe installed beneath the water level in the borehole at the time of installation. When the well assemble is anchored, the prepacked seals are submerged under water. The prepacked seals are allowed to hydrate in accordance with the manufacturer's instructions.
- The annular space above water level in the borehole, from the top of the prepacked bentonite seal to the base of the surface seal, shall be filled using the procedure for "DPT installation of annular seal above water level in well" below (#4). A surface seal and well head shall be completed in accordance with Appendix B.
- As with all well construction, all quantities of sealing materials used shall be measured in units of volume and reported in the well log report.

b) Procedure for Anchoring Well Assembly

(1) Affix the expendable drive point to the bottom push rod and advance the push rods to the designed maximum depth of the well.

(2) Lower pre-packed screen down the push rod with the appropriate end pointing down, per manufacturer's instructions. Add screen sections as needed to achieve the designed screened interval.

(3) Thread the prepacked bentonite sleeve to top of screen.

(4) Lower the well screen and seal into the push rods. Add additional pre-packed bentonite seals so that pre-packed seals will seal all of the annular space below the water level in the borehole. The pre-packed seals will function as an annular seal below the water table and as a transition seal/grout barrier for the annular seal installed above the water table.

(5) Do not use pre-packed seals above the water table because the proper expansion of the seal cannot be assured in unsaturated conditions. Add PVC riser pipe above the prepacked bentonite sleeves. Continue to add riser sections until the assembly hits the expendable drive point at bottom of rod string. At least one foot of riser should extend past the

top push rod. Plug the top riser to ensure that the inside of the well stays clean during construction.

(6) Attach the well assembly firmly to the expendable drive point in accordance with the manufacturer's instructions, ensuring that the bottom end of the screen is sealed. Gently pull up on the riser to ensure that the well assembly and anchor are firmly attached.

(7) Retract the push rods so that the bottom push rod is approximately one foot above the top prepacked bentonite sleeve. Work quickly so that the sleeves do not swell inside the push rods and come up with the rod string. If the prepacked bentonite sleeves come up with the rod string, the well installation has failed and must be immediately destroyed and sealed by tremie grouting.

(8) Allow the prepacked bentonite seals to hydrate in accordance with manufacturer's instructions before proceeding with the next steps. This can take anywhere from minutes to several hours depending on the product used.

c) Follow procedure for "DPT installation of annular seal above water level in well" below, and then construct surface completion in accordance with Appendix B.

4. DPT installation of annular seal above water level in well.

The annular space from the top of the bentonite transition seal to the base of the surface seal shall be filled using approved sealing materials and methods as specified in Appendix B.

(1) Calculate the amount of grout expected for each foot of annulus that will be filled. Mix an appropriate amount of grout material and place it in the hopper on the grouting machine.

(2) Position the grout tube just above the bentonite transition seal.

(3) Retract two push rods (approximately six feet total length) while simultaneously pumping grout. Hold the grout tube down while retracting the rods. When pausing rod retraction to remove a rod, stop the grout pump to prevent flooding rods with grout.

(4) Continue retracting the push rods while simultaneously pumping grout until rods are out of ground. Stop the grout pump at each rod break and pull approximately one push-rod length of grout tube out of the hole or hold tube while retracting rods so that tube comes up with rods.

(5) Pull grout tube from hole until the end is above ground surface, pumping grout as needed to keep hole full.

(6) When level of grout in hole stabilizes, put end of grout tube in bucket and pump clear water through until clear water runs into the bucket. Shut off grout pump.

(7) Pull the remaining grout tube through the push rods.

(8) Cut or unthread casing approximately 6 inches above ground surface and remove excess casing. Cap well temporarily with slip cap.

(9) Construct a standard well surface completion in accordance with the specifications in Appendix B of the SAM manual. Note that curing concrete can potentially generate enough heat to melt the riser pipe. Consider protecting the riser pipe from the curing concrete with a PVC conductor casing. The annular space between the riser pipe and conductor casing must be sealed with annular sealing material.

5. Open hole installation of well, transition seal, and annular seal.

a) Overview

This section provides criteria to be used for open-hole construction of groundwater monitoring wells in small-diameter soil borings. An open hole for the purpose of this guideline is a hole less than 20 feet deep with hole walls that will be stable if unsupported. Open-hole construction of wells in small diameter borings will be limited to borings and wells no greater than 20 feet in depth from the ground surface. The proper placement of the well casing and annular materials (sand pack, well seal, etc.) and an appropriate method of verifying the placement is a requirement of this method of well construction. Centralizers must be used at the bottom, top, and at an appropriate location in the middle of the well assembly. Following are criteria to be used for open-hole construction of wells in small diameter borings.

b) Subsurface Geologic Conditions

Because the borehole must remain open during construction of the well, geologic materials must be of a type not given to caving, sloughing, expansion, heaving, flowing, or other characteristics that would cause closure or in-filling of an open borehole. The project site and subsurface geologic conditions must be evaluated by the qualified professional (as specified in Appendix B), and a certification be made that the site geologic conditions are suitable for open-hole construction of wells. Accompanying the application for a permit, a summary of the evaluation must be included to justify the use of this method.

c) Well Construction

With the exception of provision of a 2-inch annular space between the well casing and boring walls, wells constructed in small-diameter borings must meet

the requirements of the State well standards and the SAM Program regarding the following:

- Placement and location of well screen relative to the water table;
- Placement of annular materials including sand filter pack, bentonite well seal, and surface seal;
- Construction of well surface completion; and
- Well development.

In addition to these requirements, centralizers are required at the bottom, top, and at an appropriate location in the center of the well assembly.

d) Verification of Well Construction

During placement of annular materials during typical well construction, depth to annular materials (sand filter pack, bentonite seal, grout backfill) is monitored or "tagged" usually with a weighted measuring tape or similar devise. The small annular space in wells constructed in small-diameter borings would not allow the use of similar methods for measuring the depth of emplacement of the annular materials. A rigid measuring device must be used for such measurements during well construction in small-diameter borings. The rigid device must not collapse or bend during the process of obtaining measurements, must be long enough to reach to the bottom of the borehole, and must be small enough to be inserted in the annular space between the well casing and borehole walls.

D. Definitions

Annular Bridge – A manufactured device designed to provide a bridge above the screened interval to prevent granular bentonite from reaching the screened interval during transition seal emplacement. This is a small device made of an expanding material such as foam.

Annular Space – The void space between an outer cylinder (such as a borehole wall or a push rod) and an inner cylinder (such as a well screen or riser pipe).

DEH – The County of San Diego Department of Environmental Health.

DPT – Direct Push Technology. Equipment that drives tools into the ground without augering a borehole.

Expendable drive point – A sacrificial metal conical tip that is left in the ground to act as an anchor point and bottom cap for a direct-push well.

ID – Inside diameter; the diameter of a pipe or rod as measured from the inside edges.

OD – Outside diameter; the diameter of a pipe or rod as measured from the outside edges.

Prepacked bentonite seal – A commercially manufactured annular seal consisting of PVC riser pipe wrapped with material that temporarily encloses bentonite. The prepacked seal is designed to be installed through DPT push rods. When the rods are withdrawn and the seal comes in contact with groundwater, the bentonite expands, rupturing the enclosing material and filling the annular space between the riser pipe and the borehole wall. The prepacked bentonite seal must be certified by the manufacturer to completely seal the annular space created by the outside diameter of the push rods. Prepacked bentonite seals must be allowed to hydrate in accordance with manufacturer's specifications before an annular seal is installed in the unsaturated zone. **Prepacked bentonite seals are not to be used above the water table.**

Prepacked well screen – A commercially manufactured well intake device consisting of slotted PVC pipe wrapped with a sandwich of screen holding a layer of appropriately sized silica sand.

PVC – Polyvinyl chloride.

SAM – The County of San Diego Department of Environmental Health Site Assessment and Mitigation Program.

Schedule 40 -- Pipe manufactured to meet ASTM D1785 Schedule 40 specifications.

Small Diameter Well - A "small diameter well" for the purpose of this document is a well that cannot be constructed by conventional methods due to the borehole being less than 6 inches diameter with a proper 2 inch annual space around the casing

Well riser pipe - The non-perforated pipe inserted into the well borehole that connects the well screen with the ground surface.

E. References

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